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EXTRACTION TESTING OF WOOD-SCREW-SECURED TIEDOWNS

John M. Kortz

Army Transportation Engineering Agency
Fort Eustis, Virginia

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EXTRACTION TESTING
OF WOOD-SCREW-SECURED TIEDOWNS

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Prepared by

John M. Kortz, 1LT, TC

Engineering Research Division
U.S. ARMY TRANSPORTATION ENGINEERING AGENCY
MILITARY TRAFFIC MANAGEMENT AND TERMINAL SERVICE
Fort Eustis, Virginia 23604

ABSTRACT

An engineering test exploring the feasibility of using 5,000-pound-capacity floor tiedowns for securing U.S. Army aircraft in commercial and military van containers was conducted by Engineering Research Division, U.S. Army Transportation Engineering Agency, Military Traffic Management and Terminal Service, Fort Eustis, Virginia. The tiedowns were secured alternately to four species of wood (representing types of wood used in container floors) by wood screws, and the screws extracted by applied loads from the wood at angles of 90 degrees and 45 degrees by a universal testing machine. A working load of 30 percent of the failure load was applied to the tiedown system and held for 1/2 hour, with no yield observed. The results of the laboratory tests showed the tiedown system to be structurally adequate under static loads. A recommendation was made to install these tiedowns in a van container and subject them to dynamic loads in field tests using salvaged aircraft.

CONTENTS

I. INTRODUCTION

The U.S. Army Transportation Engineering Agency (USATEA), Military Traffic Management and Terminal Service, Fort Eustis, Virginia, is presently investigating the possibility of shipping sectionalized U.S. Army aircraft by standard commercial and military van containers. One phase of this investigation involves determining a tiedown configuration which is capable of restraining the aircraft component within the container and which will not permanently damage or weaken the floor of the container.

II. OBJECTIVES

1. To determine the static load which will pull a specific tiedown configuration from various species of wood used in container floors.

2. To ascertain a structurally adequate tiedown which will cause no permanent damage to or weakness in container floors.

3. To determine if a particular tiedown configuration, laboratory tested, could be considered adequate for installation in containers for field tests.

III. CONCLUSIONS

1. The tiedown configuration tested under static conditions is structurally adequate for further tests involving dynamic loads.

2. Ease of installation and ease of procurement of the components of the tiedown make this configuration a logical choice for further testing.

3. This tiedown configuration will cause no permanent damage to or weakening in container floors. The screws used for this test left four 7/8-inch-deep holes, less than 1/4-inch in diameter, which can easily be filled with plastic wood filler.

IV. RECOMMENDATIONS

1. That field tests be performed, using this tiedown configuration to confirm its usability and structural adequacy.

2. That salvaged aircraft be used in these field tests in the event that the tiedowns prove structurally inadequate under dynamic loads.

3. That wood screws in pilot holes be started by turning them rather than by driving with a hammer, in order to utilize fully the available thread length of the screw.

4. That further testing begin immediately so that an adequate restraining system will be available when the need arises.

V. PROCEDURES

One tiedown configuration was tested, using four species of wood. The tiedown was a Ring Assembly, Tiedown, FSN 1560-928-6296, and its Adapter Assembly, Tiedown, FSN 1560-909-8741, as removed from the floor of a CH-47 Helicopter, and rated at 5,000 pounds capacity (Figure 1). This tiedown assembly was secured to each wood specimen, in turn, with four No. 12 (0.216-inch diameter) 1-1/4-inch-long steel wood screws. Pilot holes of 0.182-inch diameter were drilled for each wood screw. This size was chosen because the National Design Specification for Stress-Grade Lumber and its Fastenings (1968), published by the National Forest Products Association, recommends a maximum pilot-hole diameter in hardwoods of 90 percent of the screw diameter. The wood species tested were white oak, beech, white ash, and a soft variety of pine. The three hardwood specimens were of FAS (First and Second) grade and met or exceeded the specifications for acceptable grade in Fruehauf Engineering Standard Number 3[illegible] (Appendix). A 300,000-pound-capacity Tinius-Olsen Universal Testing Machine was used for applying the withdrawal loads (Figure 2).

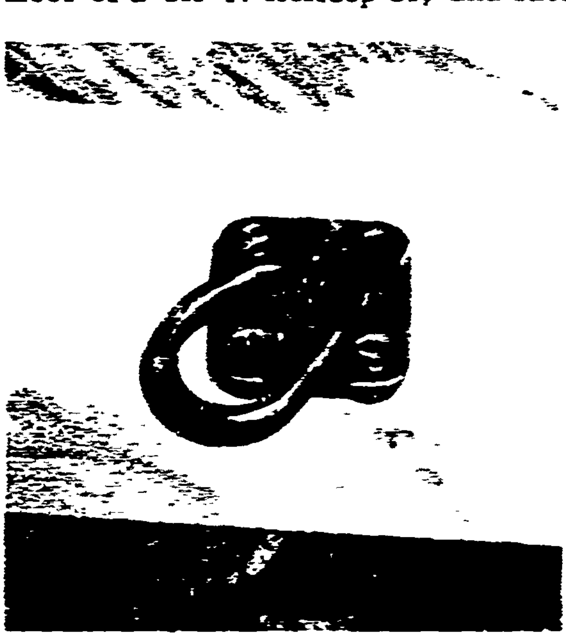

Figure 1. Tiedown Ring Assembly.

In the first phase of testing, loads were applied slowly at both 90 degrees and 45 degrees to the wood surface until the wood screws securing the tiedown withdrew from the wood specimen (Table 1). Each test was run twice, and after an average withdrawal load for each wood species was computed, a working load of 30 percent of withdrawal load (chosen to represent a sufficient safety factor) was applied and held for 1/2 hour to check for yielding (Table 2).

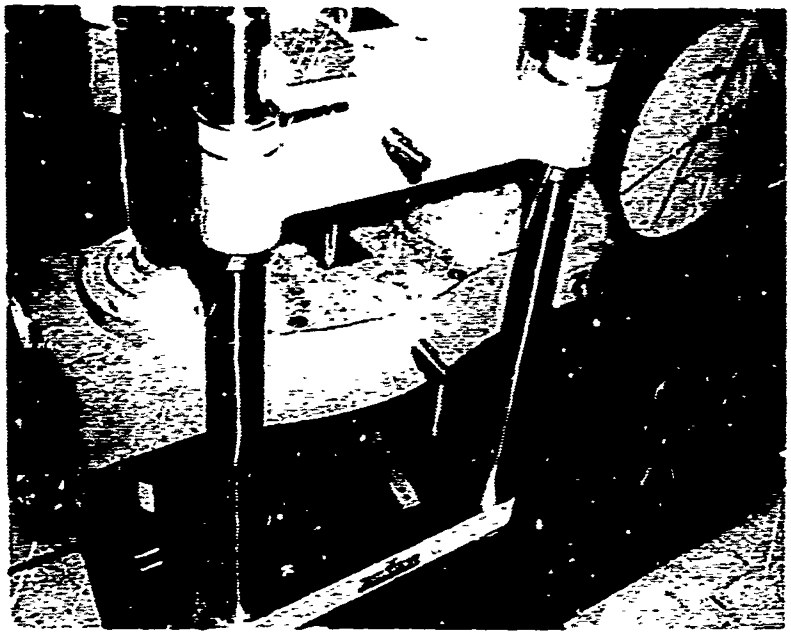

Figure 2. Tinius-Olsen Universal Testing Machine.

TABLE I
MAXIMUM LOAD WITHDRAWAL TESTS

Test No.	Test Angle (°)	Wood Species	Withdrawal Load (lb)
1	90	White Oak	2,975
2	90	White Oak	2,800
3	90	Pine	2,500
4	90	Pine	2,450
5	90	Beech	4,225
6	90	Beech	4,300
7	90	White Ash	2,525
8	90	White Ash	2,475
9	45	White Oak	1,725
10	45	White Oak	1,850
11	45	Pine	1,225
12	45	Pine	2,150
13	45	Beech	2,800
14	45	Beech	2,850
15	45	White Ash	1,800
16	45	White Ash	1,725
17	45	Pine	2,000

Pilot Hole Diameter: No. 14 bit, 0.182-inch
Pilot Hole Penetration: 3/4-inch
Screw (Thread) Penetration: 7/8-inch (3/4-inch)
Screw Type: Wood Screw No. 12
Screw Length: 1-1/4 inches

TABLE II
WORKING LOAD WITHDRAWAL TESTS*

Test No.	Test Angle (°)	Wood Species	Average Withdrawal Load (lb)	Working Load** (lb)	Yield (in.)
18	90	Pine	2,475	743	None
19	90	White Oak	2,887	866	None
20	90	Beech	4,263	1,280	None
21	90	White Ash	2,500	750	None
22	45	Pine	1,791	537	None
23	45	White Oak	1,787	536	None
24	45	Beech	2,825	848	None
25	45	White Ash	1,763	529	None

*Applied for 1/2 hour in each test.
**30 percent of average withdrawal load.

Two tiedowns were tested simultaneously for the 90-degree tests (Figure 3). This assured withdrawal from the weaker of the two wood specimens. Therefore, the two values recorded for static withdrawal at 90 degrees are the two lesser strength values of four tiedown configurations used in the two tests.

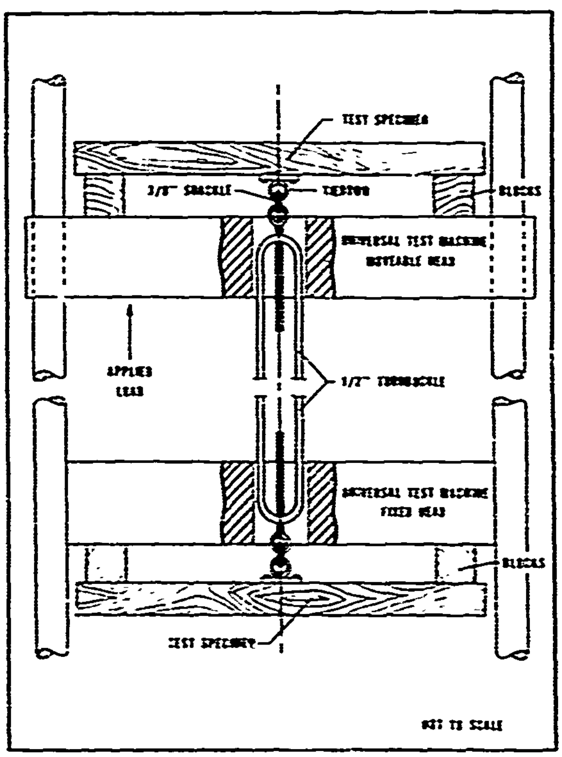

Figure 3. 90-Degree Extraction Test.

The 45-degree tests were performed on each specimen individually (Figure 4). A 1/2-inch-diameter turnbuckle with 3/8-inch-diameter shackles at each end was used between the tiedowns being tested.

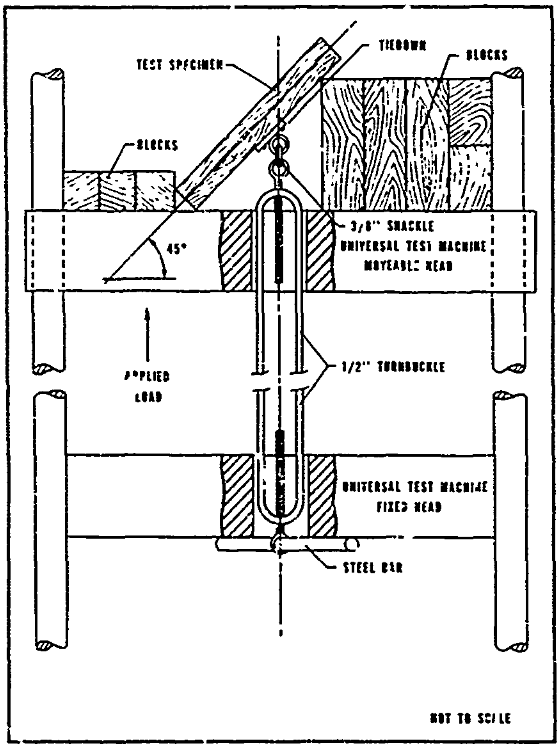

Figure 4. 45-Degree Extraction Test.

VI. TRANSPORTATION ENGINEERING ANALYSIS

Tables 1 and 2 summarize the tests performed. The hardwoods were tested to simulate container floors, while the pine was tested to compare hardwoods and softwoods and to simulate rough field conditions when container floors may be in such poor shape that screws may be withdrawn more easily than under laboratory conditions. Actually, the pine was observed to have greater resistance to withdrawal at 45 degrees than white ash and white oak (see Table I).

The withdrawal angles were chosen because 90 degrees demonstrated the maximum resistance to withdrawal, and 45 degrees represented field conditions where tiedowns will usually be stressed at some angle from the vertical between 30 degrees and 60 degrees. The probable maximum accelerations to which these tiedowns may be subjected will be on the order of 2g's. As the maximum weight of economically containerizable sectionalized U.S. Army aircraft is under 2,000 pounds, and as four or

more tiedowns will probably be used for each aircraft, laboratory testing has established the structural adequacy of this tiedown configuration for securing these aircraft with a sufficient safety factor, pending field tests, or further laboratory tests using dynamic loads.

APPENDIX

EXTRACT: PARAGRAPH C
FRUEHAUF ENGINEERING STANDARDS NO. 32
(1961 - REVISED 1967)

C. Grade

Finished flooring shall comply with the following limitations:

		Face	Back
1.	Season Checks	Not permitted.	Not permitted.
2.	Sound Sapwood	Permitted.	Permitted.
3.	Knots	1/4 inch diameter sound and tight knots permitted. No two knots closer than 10 inches.	Sound and tight knots permitted.
4.	Skips	Surface skips permitted provided thickness of floor at point of skip is not less than 1/16 inch below nominal thickness of floor - length of skip may be no longer than 1 inch and aggregate length of all skips on one board may not be greater than 12 inches.	Surface skips permitted provided thickness of floor at point of skip is not less than 1/16 inch below nominal thickness of floor-floor skips of aggregate length of all components of one board may not be greater than length of that board.
5.	Pin, Spot & Shot Worm Holes	Permitted to 1/4 inch diameter and not penetrating thru board. Scattered and not to exceed an average of one per square foot -- hole to be filled.	Same as face.
6.	End Splits	Not permitted.	Not permitted.
7.	Stains, Streaks & Spots	Permitted if wood is sound.	Permitted if wood is sound.

UNCLASSIFIED

Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft Containerization						
Aircraft Tiedowns						
Wood Screw Extraction Values						